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Improving the Penalty-free Multi-objective Evolutionary Design Optimization of Water Distribution Systems

Authors : Emily Kambalame

Abstract : Water distribution networks necessitate many investments for construction, prompting researchers to seek cost reduction and efficient design solutions. Optimization techniques are employed in this regard to address these challenges. In this context, the penalty-free multi-objective evolutionary algorithm (PFMOEA) coupled with pressure-dependent analysis (PDA) was utilized to develop a multi-objective evolutionary search for the optimization of water distribution systems (WDSs). The aim of this research was to find out if the computational efficiency of the PFMOEA for WDS optimization could be enhanced. This was done by applying real coding representation and retaining different percentages of feasible and infeasible solutions close to the Pareto front in the elitism step of the optimization. Two benchmark network problems, namely the Two-looped and Hanoi networks, were utilized in the study. A comparative analysis was then conducted to assess the performance of the real-coded PFMOEA in relation to other approaches described in the literature. The algorithm demonstrated competitive performance for the two benchmark networks by implementing real coding. The real-coded PFMOEA achieved the novel best-known solutions ($419,000 and $6.081 million) and a zero-pressure deficit for the two networks, requiring fewer function evaluations than the binary-coded PFMOEA. In previous PFMOEA studies, elitism applied a default retention of 30% of the least cost-feasible solutions while excluding all infeasible solutions. It was found in this study that by replacing 10% and 15% of the feasible solutions with infeasible ones that are close to the Pareto front with minimal pressure deficit violations, the computational efficiency of the PFMOEA was significantly enhanced. The configuration of 15% feasible and 15% infeasible solutions outperformed other retention allocations by identifying the optimal solution with the fewest function evaluation

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